Public Release DRAFT

Dioxin and Furan
Estimated Air Emissions
for Maine

Fall 2000

Maine Department of Environmental Protection
Bureau of Air Quality
Division of Technical Services
Air Toxic Unit

Ellen E. Parr-Doering
and
Douglas J. Saball

Revision: January 9, 2001
(Reformatted by David Wright June 23, 2004)

Dioxin and Furan Estimated Air Emissions for Maine-Fall 2000

Table of Contents

Tables and Figures

Appendices

SECTION 1. INTRODUCTION

1.1 Purpose of Document

Section 585-C of M.R.S.A. Title 38 authorizes the Department of Environmental Protection to conduct and maintain an inventory of Maine sources emitting hazardous air pollutants (HAPS). This inventory is a partial fulfillment of maintaining, and updating, the number, location, and quantity of emissions associated with emitters of dioxin/furans in the state.

The primary resource for this activity was the EPA Draft document "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a), April 1998, which contains the most recent dioxin Total; Equivalent Toxicity (TEQ) emission factors available.[1] The dioxin/furan (CDD/CDF) TEQ emission rates in this report are estimates only. These CDD/CDF TEQ emission estimates are typically calculated as a product of an emission factor and annual estimate of source activity. Both the emission factors and the source activity level estimates contain inherent uncertainties and may not accurately depict the actual emission rates. Typically, emission factors are based on a limited set of test data that have measurement errors and that may not be representative of the sources being studied.

Accurate knowledge of CDD/CDF TEQ emission in Maine is important for a number of reasons. Dioxins have been identified as a potential health hazard in Maine via ingestion of fish contaminated with CDD/CDF. The amount of CDD/CDF in Maine's rivers is sufficiently high to have warranted a 1992 fish advisory, for consumption of fish caught from Maine rivers. The following is an excerpt from a DEP press release on July 26, 1996. See Appendix A for press releases

> The current language advises "women of child-bearing age not to eat fish from the Androscoggin River, Kennebec River below Skowhegan, and Penobscot River below Lincoln." The same advisory recommends limits for the general population—one meal per month of fish from the Androscoggin and two meals per month of fish from the designated sections of the Kennebec and Penobscot.[2]

The 2000 fish consumption advisory expanded the above list of rivers and includes a fishmeal guideline. This is because the recent consumption advisories are geared to encourage proper fish consumption under the premise that general consumption of fish is healthy.

> "Fish caught in some Maine waters have high levels of PCBs, Dioxins or DDT in them. These chemicals can cause cancer and other health effects. The Bureau of Health recommends <u>additional</u> fish consumption limits on the waters listed below. <u>Remember</u> to check the mercury guidelines. If the water you are fishing is listed below, check the mercury guidelines and fallow the most limiting guidelines." See Appendix B for a copy of the warning, or visit http://janus.state.me.us/dhs/bohetp/fca.htm[3]

This study evaluates the mass and rate of CDD/CDF emissions in the State of Maine. The sources of CDD/CDF emissions that are addressed include but are not limited to;

- Cement production,
- Pulp and paper production,
- Utility steam generating units,
- Medical waste incinerators,
- Municipal waste combustion units,
- Tire incineration,
- And other sources, including area sources.

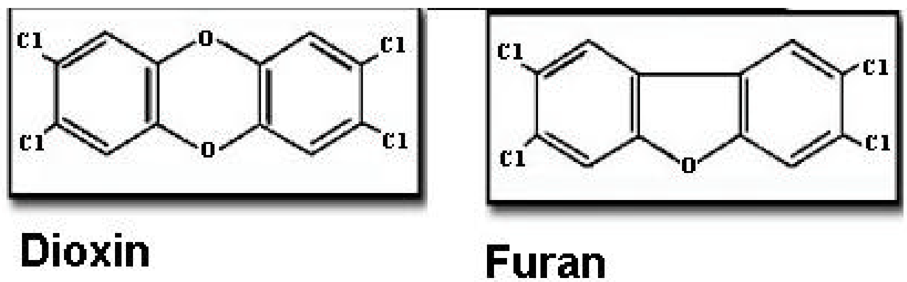
---

[1] EPA Draft *"Inventory of Sources of Dioxin in the United States."* (EPA/600/p_98/002a), Office of Research and Development, Washington D.C., April 1998.
[2] Maine DEP *Press Release – DEP issues Report on Dioxin Monitoring*, Augusta, Maine: Department of Environmental Protection, July 26, 1996.
[3] Maine DHS *2000 Freshwater Fish Consumption Advisory*, Maine Bureau of Health, Environmental Toxicology Program, August 29, 2000.

1.2 Nature of the Pollutant

A dioxin is any compound that contains the chlorinated dibenzo-p-dioxin nucleus (CDD). A furan is any compound that contains the dichlorinated dibenzofuran nucleus (CDF). See Figure 1. The only differences between members within a dioxin or a furan are in the number and positions of the chlorine atoms. There are 75 possible dioxin isomers and 135 possible furan isomers.

Figure 1: Dioxin and Furan Compound Structures.



Source: EPA Locating and Estimating Air Emissions form Sources of Dioxins and Furans (EPA DCN No. 95-298-130-54-01)

The CDD/CDF represent a group of chemicals with volatility that decreases as the number of chlorine atoms in the isomer increases. Because these compounds are not very soluble in water and have overall low volatility, the CDD/CDF are much more likely to be found in soil, or sediment, or as particulate matter, than as gaseous pollutants in the air. Generally, these compounds are highly lipophillic (tend to adsorb to fatty molecules), and tend to bioaccumulate. If the CDD/CDF are emitted from a stationary source under elevated temperatures, the isomers containing four or more chlorine atoms tend to be largely particulate matter or condensable, while the more volatile ones may exist in the gaseous state (depending on temperature and particulate loading). At lower temperatures and with higher particulate loading (i.e., a relatively cool aerosol), the particulate/ condensable properties will be enhanced.[4]

1.3 Formation of CDD/CDF

CDD and CDF have no known technical use and are not intentionally produced. There is no evidence to suggest that dioxins and furans are formed biosynthetically by living organisms.[5] CDD/CDF are formed as unwanted byproducts of certain chemical processes during the manufacture of chlorinated intermediates, in the combustion of chlorinated materials, and combustion of material in the presence of chlorine atoms.[6] There are three general mechanisms believed to result in emissions of CDD/CDF from combustion systems.

- Incomplete destruction of CDD/CDF present in the source during the combustion process.
- Low temperature downstream formation in the flue gas ductwork or across the air pollution control device.
- And the formation of CDD/CDF from “precursor” materials in the furnace, such as polychlorinated biphenyls (PCB), polychlorinated phenols (PCP), and polyvinyl chloride (PVC).

---

[4] U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*, Draft ed. EPA 95-298-130-1. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, December 1996

[5] Ibid.

[6] U.S. EPA. *Compilation of Air Pollutant Emission Factors*, 5th ed. (AP-42), Vol. I: Stationary Point and Area Sources, Section 1.10, Residential Wood Stoves. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1995.

1.4 Emission Factors

The available data on some potential sources of CDD/CDF emissions in Maine is limited. **The reader is strongly cautioned against using the emissions information contained in this document to develop an exact assessment of emissions from a specific facility.** Available data are insufficient to develop statistical estimates of the accuracy of these emission factors, so no estimate can be made of the error that could result when these factors are used to calculate emissions from any given facility. It is possible in some cases that an orders-of-magnitude difference could result between actual and calculated emissions, depending on source configuration, control equipment, and operating practice. Therefore, when accurate source-specific emissions are desired, that source-specific information needs to be obtained to confirm the existence of particular emitting operations, the types and effectiveness of control measures, and the impact of operating practices. A source test should be considered as the best means to determine air emissions directly from a facility or operation.

An effort was made during the development of this report to utilize the most recent emission factors available. The EPA Draft document "Inventory of Sources of Dioxin in the United States" compiled the most recent data as of April 1998.[7] It compared information and data from recently published reports, collectively referred to as the *"Dioxin Reassessment Reports"* by the Office of Health and Environmental Assessment (OHEA), U.S. Environmental Protection Agency, Washington, DC.[8] The emission factors presented in the EPA inventory document were for the most part developed from the same information sources and are consistent between the reports as well as with the most current version of the EPA document *"Compilation of Air Pollutant Emission Factors"* (AP-42).[9] Differences in reported emission factors did occur for the municipal waste combustion category due to the inclusion of additional and more current test data in the development of the EPA inventory document.

CDD and CDF are not intentionally manufactured but are byproducts of certain chemical processed during the manufacture of chlorinated intermediates, the combustion of chlorinated materials, and the combustion of material of in the presence of chlorine atoms. Sources of CDD/CDF emissions include waste incineration, stationary fuel combustion, crematories, metal foundries and recovery facilities, Kraft pulp and paper production, internal combustion engines, carbon regeneration, biomass burning, organic chemical manufacture, wood treatment, and Portland cement manufacturing.[10]

EPA using one of two basic approaches developed emission factors for each category/subcategory. The first and preferred approach was to utilize emission estimates developed by the EPA's Office of Air Quality Planning and Standards (OAQPS). The OAQPS project teams in charge of developing Maximum Achievable Control Technology (MACT) standards, or other EPA projects where in-depth evaluation and characterization of the source categories were conducted (e.g., Secondary Lead Smelting NESHAP) have the most reliable emission factors. The second approach was to identify category-specific national activity data (i.e., throughput, production, fuel use, etc.) and to use emission factors and available information on industry characteristics and control levels to develop a national emission estimate. The availability and overall quality of national activity data varies by category. Preferred sources of national activity data are trade association and statistics compiled by several government entities {e.g., the EPA, Department of Energy, Energy Information Administration (EIA)}. Emission factors derived from actual source testing were used wherever possible. An attempt was made to utilize emission factors that reflect the standard emission control methods used by each source category.[11]

1.5 Limitations and data quality

The CDD/CDF TEQ rates in this report are estimates only due to incomplete information obtained in previous inventories. These CDD/CDF TEQ emission estimates are typically calculated as a product of an emission factor and annual estimate of source activity. Both the emission factors and the source activity level estimates contain inherent uncertainties and may not accurately depict the actual emission rates. Typically, emission factors are based on a limited set of test data that have measurement errors and that may not be representative of the sources being studied.

1.6 Toxicity Equivalency Concepts and Methodology (TEQ's)

The Total Equivalent Factor (TEF) method is an interim procedure for assessing the risks associated with exposures to complex mixtures of CDD/CDF. This method relates the toxicity of the 210 structurally related chemical pollutants (135 CDF and 75 CDD) and is based on limited data available from *in vivo* and *in vitro* toxicity testing. The toxicity of the most highly studied dibenzo-p-dioxin, 2,3,7,8-TCDD, is used as a reference in relating the toxicity of the other 209 compounds (i.e., in terms of equivalent amounts of 2,3,7,8-TCDD). This approach simplifies risk assessments, including assessments of exposure to mixtures of CDD and CDF

---

[7] Op. Cit., EPA Draft *"Inventory of Sources of Dioxin in the United States."*
[8] U.S. EPA. *Dioxin Reassessment Report*. Washington D.C.: U.S. Environmental Protection Agency, Office of the Health and Environmental Assessment, 1996.
[9] Op. Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans.*
[10] Ibid.
[11] Ibid.

such as incinerator flyash, hazardous wastes, contaminated soils, and biological media.[12] In 1989, as a result of the active involvement of EPA in an international effort aimed at adopting a common set of TEFs, International TEFs/89, or 1-TEFs/89, were implemented.[13] These concepts and methodologies are presented in this document because some emission factors and the national emission totals found in the literature are presented as TEQs.

A strong structure-activity relationship exists between the chemical structure of a particular CDD/CDF homologue and its ability to elicit a biological/toxic response in various *in viro* and *in vitro* test systems. Congeners in which the 2,3,7, and 8 lateral positions are occupied with chlorines (the"2,3,7,8-substituted homologues") are much more active than the other homologues (the "non-2,3,7,8-substituted homologues").

Available data on shirt-term *in vitro* toxicity studies for CDD/CDF are used to supplement the lack of long-term *in vivo* results for these compounds. These toxicity estimates, expressed in terms of toxic equivalents (TEQs), or equivalent amounts of 2,3,7,8-TCDD, are generated by using the TEF to convert the concentration of a given CDD/CDF into an equivalent concentration of 2,3,7,8-TCDD. The I-TEQs/89 are obtained by applying the I-TEFs/89 to the congener-specific data and summing the results. In assigning TEFs, priority is normally given to the results from long-term studies followed by the results from short-term, whole-animal studies.[14]

The I-TEF/89 approach expresses the TEFs as a rounded order of magnitude because, with the exception of the I-TEF/89 for PeCDF, the I-TEFs/89s are only crude approximations of relative toxicity. A value of 0.5 is assigned to 2,3,4,7,8-PeCDF; 1,2,3,7,8-PeCDF is assigned a value of 0.05. This higher value for the 2,3,4,7,8-PeCDF is supported by data from *in vivo* and *in vitro* studies and is the only instance in which the I-Tefs/89s depart from the guiding principle of simplicity in which TEFs are expressed as rounded orders of magnitude. The I-TEF/89 scheme assigns a value of zero to non-2,3,7,8-substituted homologues. A value of 0.5 is assigned to 1,2,3,7,8-PeCDD, but the 13 other PeCDD are assigned a value of zero.[15]

In general, an assessment of human health risk of a mixture of CDD and CDF using the TEF approach involves the following steps:[16]

1. Analytical determination of the CDD and CDF in the sample.
2. Multiplication of homologue concentrations in the sample by TEFs to express the concentration in terns of 2,3,7,8-TCDD equivalents.
3. Summation of the products in Step 2 to obtain the total 2,3,7,8-TCDD equivalents in the sample.
4. Determination of human exposure to the mixture in question, expressed in terms of 2,3,7,8-TCDD equivalents, (i.e., TEQs).
5. Combination of exposure from Step 4 with toxicity information on 2,3,7,8-TCDD (usually carcinogenicity and /or reproductive effects to estimate risks associated with the mixture.

In cases where the concentrations of homologues are known:
2,3,7,8-TCDD Equivalents = ∑(TEF of each 2,3,7,8-CDD/CDF homologue)*the concentration of the respective homologue+∑ (TEF of each non 2,3,7,8-CDD/CDF homologue)*the concentration of the respective homologue

[12] Op. Cit., AP-42, 5th ed., Section 1.10, Residential Wood Stoves. 1995.
[13] Op. Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans.*
[14] Ibid.
[15] Ibid.
[16] Ibid.

Table 1: INTERNATIONAL TOXICITY EQUIVALENCY FACTORS/89

Compound	I-TEFs/89
Mono-, Di-, & Tri-CDDs	*0*
2,3,7,8-TCDD	1
Other TCDDs	0
1,25,3,7,8-PeCDD	0.5
Other PeCDDs	0
2,3,7,8-HxCDD	0.1
Other-HxCDD	0
2,3,7,8-HpCDD	0.01
Other-HpCDD	0
OCDD	0.001
Mono-, Di, & Tri-CDDFs	0
2,3,7,8-TCDF	0.1
Other-TCDF	0
2,3,4,7,8-PeCDF	0.5
1,2,3,7,8-PeCDF	0.05
Other-PeCDF	0
2,3,7,8-HxCDF	0.1
Other-HxCDF	0
2,3,7,8-HpCDF	0.01
Other-HpCDF	0
OCDF	0.001

Source: EPA Locating and Estimating Air Emissions form Sources of Dioxins and Furans (EPA DCN No. 95-298-130-54-01)

SECTION 2. SOURCES IN MAINE

2.1 Overview

Maine sources of atmospheric emissions of dioxin/ furans (CDD/CDF) are described in this section. Many of the source categories discussed emit CDD/CDF from a fuel combustion process. Emission factors for the processes are presented when available, and control technologies are described. There are few emission control techniques that are dedicated solely to reduce CDD/CDF emissions, and therefore data on the effectiveness of control strategies in reducing CDD/CDF emissions are very limited. In many cases, the emission factor data available were for both controlled and uncontrolled processes and/or units. Application of the appropriate emission factor is applied to the combustion or process rate to determine the estimated CDD/CDF emissions in TEQs.

2.2 Determination of Emission Sources

Utilizing the list of Source Classification Codes (SCC) available in the EPA L&E document, a list of potential sources in Maine was formulated. Further examination of the emission factors associated with each category determined the variable to be entered. For most categories a pound emissions per ton (lb./ton) of combustion or process was used. For mobile sources a pound per mile (lb./mile) approach was used. Most of the data for Maine sources was derived from the DEP Criteria Pollutant Inventory for 1996.[17] Presently, several of the sources in Maine have not been quantified, (e.g., secondary metal smelters, open and agricultural burning). In this document an attempt is made to identify these potential sources, and the data needed to determine an emissions estimate. In future documents these sources should be quantified.

2.3 Residential Combustion

2.3.1 Background

The residential combustion source includes furnaces, stoves, and fireplaces burning coal, oil, gas, and wood to produce heat for individual homes. Emission factors are available for residential coal, oil, and wood combustion. Gas-fired furnaces, which are considered to be miniscule sources of CDD/CDF, are not included here. Residential wood combustion devices include furnaces, fireplaces, and woodstoves. Fireplaces are used primarily for supplemental heating and for aesthetic effects.

[17] Maine DEP. *Maine Fuel/Process Rates Totals for 1996*, (ReportSmith edition), Augusta, Maine: Department of Environmental Protection, 1998.

The combustion of fossil fuels or wood in residential units (woodstoves, furnaces, and fireplaces) is a relatively slow and low-temperature process. Because combustion in the residential sector tends to be less efficient than in commercial or industrial sectors, the potential to form CDD/CDF may be greater. Also, inadequate maintenance of these units may increase potential for CDD/CDF formation on particulate matter. Furthermore, residential combustion units are generally not equipped with gaseous or particulate control devices.

Coal furnaces operate at comparatively low temperatures and, therefore do not efficiently combust fuel. Because coal contains small quantities of chlorine and CDD/CDF precursors the potential for CDD/CDF formation exists. Emissions from fuel oil combustion depend on the grade and composition of the oil, the design of the furnace, and the level of equipment maintenance. Oil contains only small amounts of chlorine and CDD/CDF precursors.[18]

Woodstoves are used in residences as space heaters to supplement conventional heating systems. Combustion efficiencies for woodstoves are dependent on stove design and operating characteristics; consequently, emissions vary greatly among woodstoves. Woodstoves have a greater potential to emit CDD/CDF than fossil fuel-fired units due to the likelihood of chlorine or CDD/CDF precursors present in wood.

2.3.2 Emissions

As mentioned previously, residential combustion sources do not generally use air pollution control devices. Coal-fired residential combustion sources are generally not equipped with PM or gaseous pollutant control devices. Changes in stove design and operating practices, however, have been made to lower PM, hydrocarbon, and CO emissions in recent years. The effect on CDD/CDF emissions from controls that are used for these pollutants has not been studied.

Wood stove emissions reduction features include baffles, secondary combustion chambers, and catalytic combustors. Catalytic combustors or converters are similar to those used in automobiles. Wood stove control devices may lose efficiency over time. Control degradation for any stoves, including noncatalytic woodstoves, may occur as a result of deteriorated seals and gaskets, misaligned baffles and bypass mechanisms, broken refractors, or other damaged functional components.[19] In addition, combustion efficiencies may be affected by differences in the sealing of the chamber and control of the intake and exhaust systems.[20 21]

The emission factor for coal-fired residential furnaces was taken from the EPA "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a) document. This emission factor is based on the TEQs derived from average CDD/CDF particulate concentrations profiles from chimney soot samples collected from 7 coal ovens, and particulate emission factors obtained from AP-42.[22 23 24] These emission factors represent the maximum emission rates from these sources, as chimney soot and may not be representative of the particulate actually emitted to the atmosphere.[25 26]

2.3.3 Residential Coal Combustion

Because it is logistically difficult to determine emissions from each residential combustion unit the data are considered on a statewide basis in relation to consumption of coal. For 1997 the Department of Energy (DOE) and Maine State Planning office (SPO) reported that Maine used a total of 2,000 tons of coal for residential use. This amount of coal consumption was applied to the TEQ emission factor for bituminous coal, because it is the predominate coal of use for residential combustion. The emission factor for residential bituminous coal combustion is 7.50E+00 ng TEQ/kg bituminous coal combusted.[27] Applying this factor to the 2,000

---

[18] U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*, Draft ed. EPA 95-298-130-1. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, December 1996

[19] Ibid.

[20] U.S. EPA. *Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter*, Revised Draft. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, November 1994

[21] Johnson, N.D., and M.T. Schultz (ORTECH Corporation). *MOE Toxic Chemical Emissions Inventory for Ontario and Eastern North America*. Final Report No. P92-T61-5429/OG. Rexdale, Ontario: Ontario Ministry of the Environment, Air Resources Branch, 1992.

[22] EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)

[23] Op. Cit. U.S. EPA. *Compilation of Air Pollutant Emission Factors*, 5th ed. (AP-42), Vol. I: Stationary Point and Area Sources, Section 1.10, Residential Wood Stoves. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1995.

[24] Op. Cit. U.S. EPA. *Compilation of Air Pollutant Emission Factors*, 5th ed. (AP-42), Vol. I: Stationary Point and Area Sources, Section 1.9, Residential Fireplaces. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1995.

[25] U.S. DOE. *State Data Report; Computation Estimates*. Washington D.C.: U.S. Department of Energy, May 1999. http:/www.eia.doe,gov/emeu/sep/me/frame.html

[26] Maine SPO, *The 1998 Maine Energy Data Book*, Maine State Planning Office, 184 State St., SHS #38, Augusta, Maine, May 1998.

[27] Op., Cit., EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)

tons of bituminous coal reported for 1997 results in 1.36E-02 grams TEQ dioxin emitted. (Calculations and conversions are found in Section 5.2.1)

2.3.4 Residential Oil Combustion

Residential oil combustion units are relatively small and are used primarily in homes and apartments. It is logistically difficult to determine emissions from individual residential combustion units, so the data is considered on a statewide basis in relation to consumption of oil. The TEQ emission factor for residential #2 oil combustion is taken from the EPA "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a) document. This TEQ emission factor is derived from on average CDD/CDF TEQ concentrations measured from 21 furnaces used in central heating, and particulate emission rates obtained from AP-42.[28 29] For 1997, DOE and SPO reported that Maine used a total of 7,644 Thousand barrels of distillate heating oil (#2) for residential use.[30 31] Utilizing the TEQ emission factor for residential #2 fuel combustion of 1.50E+02 pg TEQ/L #2 oil combusted, applied to the 7,644 Thousand barrels of #2 fuel combustion results in 1.82E-04 grams TEQ dioxin emitted. (Calculations and conversions are found in Section 5.2.2)

2.3.5 Residential Wood Combustion

The TEQ emission factor for a residential wood combustion was taken from the EPA "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a) document. This emission factor is based TEQ profiles of average CDD/CDF concentrations measured at 18 combustion unit chimneys, and particulate emission rates obtained from AP-42.[32 33] The emission factor represents the maximum emission rates for this sources as chimney soot, and it may not be representative of the particulate actually emitted to the atmosphere.[34]

The TEQ emission factor for residential wood combustion is 2.00E+00 ng TEQ/kg wood combusted.[35] The process amount for this category was derived through the State Planing Office (SPO) and Department of Energy (DOE) numbers for 1997.[36 37] The SPO " Residential Fuelwood Use in Maine" survey showed 78.85% of the purchased wood was for wood stoves, 5.77% for fireplaces, 12.5% furnace or boiler, and 2.88% for others.[38] Of interest is that the SPO reported 25% of the people who burned wood in 1998/99 did not purchase it. Therefore the SPO and Department of Energy (DOE) numbers of how much wood is purchased for combustion is approximately 75% of the total residential wood combusted. The DOE and SPO reported 469,862 cords of wood for residential combustion was sold in 1997.[39, 40] With the 25% increase for unrecorded use of 117,465.50 cords, this resuls in a total of 587,327.5 cords of wood combusted. Applying this amount to the EPA TEQ emission factor of 2.00E+00 ng TEQ/kg wood combusted results in 2.49 grams TEQ dioxin. (Calculations and conversions are found in Section 5.2.3)

2.4 Backyard Trash Burning (BYB)

---

28 Op. Cit. U.S. EPA. *Compilation of Air Pollutant Emission Factors*, 5th ed. (AP-42), Vol. I: Stationary Point and Area Sources, Residential coal combustion. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1995.

29 Op., Cit., EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)

30 U.S. DOE. *State Data Report; Computation Estimates*. Washington D.C.: U.S. Department of Energy, May 1999. http:/www.eia.doe,gov/emeu/sep/me/frame.html

31 Maine SPO, *The 1998 Maine Energy Data Book*, Maine State Planning Office, 184 State St., SHS #38, Augusta, Maine, May 1998

32 Op., Cit., EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)

33 Op. Cit. U.S. EPA. *Compilation of Air Pollutant Emission Factors*, 5th ed. (AP-42), Vol. I: Stationary Point and Area Sources, Section 1.9, Residential Fireplaces. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1995.

34 Op. Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter*, Revised Draft. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, November 1994

35 Op., Cit., EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)

36 Op. Cit., U.S. DOE. *State Data Report; Computation Estimates*. Washington D.C.: U.S. Department of Energy, May 1999. http:/www.eia.doe,gov/emeu/sep/me/frame.html

37 Op. Cit., Maine SPO, *The 1998 Maine Energy Data Book*, Maine State Planning Office, 184 State St., SHS #38, Augusta, Maine, May 1998

38 Maine SPO, *Residential Fuelwood Use in Maine: Results of 1998/1999 Fuelwood Survey."* Maine State Planning Office, 184 State St., SHS #38, Augusta, Maine, November 1999.

39 Op. Cit., U.S. DOE. *State Data Report; Computation Estimates*. Washington D.C.: U.S. Department of Energy, May 1999. http:/www.eia.doe,gov/emeu/sep/me/frame.html

40 Op. Cit., Maine SPO, *The 1998 Maine Energy Data Book*, Maine State Planning Office, 184 State St., SHS #38, Augusta, Maine, May 1998

Determination of TEQ dioxin emissions from Back Yard Burning (BYB) was derived through application of the EPA emission factor and the process tonnage as estimated through a DEP and Department of Conservation Forestry Bureau survey. This survey consisted of town fire wardens and state forest fire rangers that estimated the process tonnage of trash for towns that do not recycle trash or have curb-side trash pick up service in 1996.[41] This report estimated that 13,021 kilograms of trash was burned daily in 1996. The EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)[42] utilized the "Evaluation of Emissions from the Open Burning of Household Waste in Barrels," (EPA-600/R-977-134a)[43] to derive the 140 ng TEQ/Kg trash burned emission factor. Application of the emission factor and the estimated tonnage results in 0.973 grams TEQ dioxin. (Calculations and conversions are found in Section 5.2.4)

2.5 Industrial Wood Combustion

2.5.1 Background

Industrial boilers are widely used primarily to generate process steam and provide space heating. Some boilers are also used for electricity generation. Industrial boilers can fire fossil and non-fossil fuels. Wood is the only non-fossil fuel discussed here, since wood-fired industrial boilers are more likely sources of dioxin/ furan (CDD/CDF) emissions due to the presence of CDD/CDF precursors in wood.

The burning of wood waste in boilers is mostly confined to those industries where it is available as a byproduct. Currently, the bulk of wood residue or bark burning in industrial boilers is carried out in forest products industrial boilers. It is burned both to obtain heat energy and to alleviate solid waste disposal problems. Wood wastes generally contain higher levels of chlorine and CDD/CDF precursors than fossil fuels. Also, wood waste has higher moisture content, which may decrease combustion efficiency. Therefore, the CDD/CDF emission potential of wood combustion is greater than that of fossil fuel combustion.[44]

Emissions of CDD/CDF from wood-fired boilers are dependent on several variables: (a) wood waste composition and variability; (b) fossil fuel type and quantity, if any, co-fired with the wood waste; (c) combustor type and performance; and (d) air pollution control systems.[45]

The composition of wood waste has an impact on CDD/CDF emissions. The composition of wood waste depends largely on the industry from which it originates. Pulping operations, for example, produce great quantities of bark that may contain more than 70 percent by weight moisture, along with sand and other noncombustibles. Because of this, bark boilers in pulp mills may emit considerable amounts of organic compounds to the atmosphere unless they are well controlled. On the other hand, some operations, such as furniture manufacturing, produce a clean dry wood waste, 5 to 50 percent by weight moisture, with relatively low particulate emissions when properly burned. Still other operations, such as sawmills, burn a varying mixture of bark and wood waste that results in particulate emissions somewhere between those of pulp mills and furniture manufacturing. Additionally, when fossil fuels are co-fired with wood waste, the combustion efficiency is typically improved; therefore, organic emissions may decrease.[46]

Combustion performance, especially the ability to provide ample air and fuel mixing and to maintain adequate temperatures for hydrocarbon destruction, are critical to minimizing emissions of CDD/CDF and precursor compounds. Key combustor design and operating parameters are ample time and temperature for drying high moisture content materials, and adequate supply and proper placement of undergrate and overfire combustion air. If the requirements are satisfied, the potential for emission of CDD/CDF is significantly reduced.[47]

2.5.2 Emissions

Several recent studies indicate that CDD/CDF emissions may increase across fabric filters, wet scrubbers, and electrostatic precipitators, (ESPs). Low-temperature *de novo* synthesis or a transformation reaction of CDD/CDF in the air pollution control equipment may cause this.[48]

---

41 Maine DEP, *State of Maine 1997 Backyard Trash Burning (BYB) Study*, Maine Department of Environmental Protection, Bureau of Air Quality, 17 State House Station, Augusta Maine.
42 Op., Cit., EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)
43 "Evaluation of Emissions from the Open Burning of Household Waste in Barrels," (EPA-600/R-977-134a)
44 Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*
45 Ibid.
46 Ibid.
47 Ibid.
48 Ibid.

The emission factor utilized for industrial wood combustion in this report came from the EPA Draft document “Inventory of Sources of Dioxin in the United States” (EPA/600/P-98/002a). These emission factors are based on several EPA test data and NCASI tests. The emission factors were applied to the amount of wood combusted by facilities that reported to the DEP for the 1996 Criteria Pollutant Inventory.[49]

These facilities report under the Source Classification Code (SCC) of "Industrial and Commercial" facilities. The following table is the estimated air emissions of CDD/CDF for "Industrial and Commercial" wood combustion without paper mill contributions. Determination of the dioxin emissions for this category was derived through the compilation of the process rates for facilities as reported to DEP for the Criteria Pollutant inventory and application of the EPA emission factors. For 1996 facilities reported 215,995 tons of wood were combusted. Application of the EPA emission factor 8.20E-01 ng TEQ/kg wood resulted in 1.61E-01 grams TEQ dioxin.

2.6 Utility Combustion of Solid and Liquid Fuels in Stationary Sources for Heat and Power Generation

2.6.1 Background

Utility boilers burn coal, oil, wood and natural gas to generate steam for electricity production. Sources that burn fossil fuels generally have extremely low CDD/CDF emissions potential as the fuel used contains only small amounts of chlorinated compounds that can form CDD/CDF. Boilers that burn wood to generate electricity have a higher CDD/CDF emission potential, because of the greater amounts of CDD/CDF precursors present in the wood.

2.6.2 Emissions

2.6.2.1 Oil

The emissions from commercial residual oil combustion was calculated by applying the EPA emission factor of 2.00E+02 pg TEQ/L to the 1996 DEP Criteria Inventory reported amount of 53,026 thousand gallons of residual oil. This resulted in an estimated 4.01E-02 grams TEQ dioxin emitted.

2.6.2.2 Coal

The calculated CDD/CDF emissions from coal-fired units in Maine were insignificant due to the limited use of coal for electric generation in the state.

2.6.2.3 Natural Gas

The EPA did not identify levels of CDD/CDF from gas-fired boilers because emissions are assumed to be insignificant compared to other fossil fuels; therefore, emission estimates are not available.

2.6.2.4 Wood

Determination of the dioxin emissions for wood fired units was derived through the compilation of the process rates for these facilities as reported to DEP for the 1996 Criteria Pollutant inventory and application of the EPA emission factors. For 1996 electric generation facilities reported 1,341,731 tons of wood was combusted. Application of the EPA emission factor 8.20E-01 ng TEQ/kg wood combusted resulted in 9.98E-01 grams TEQ dioxin.

2.7 Paper Mills

Paper mills have several sources of dioxin/ furan (CDD/CDF) air emissions. CDD/CDF are primarily produced of wood, bark, and wood waste combustion. Other sources of CDD/CDF air emissions from paper mills include black liquor combustion, and tire combustion. Paper sludge and paper pellet combustion are also a suspected sources of CDD/CDF from paper mills, but emission factors have not yet been developed.

2.7.1 Wood Combustion at Paper Mills

2.7.1.1 Background

The purpose of burning wood waste at paper mills is to obtain heat energy and to alleviate solid waste disposal problems. Wood wastes generally contain higher levels of chlorine and CDD/CDF precursors than fossil fuels. Also, wood waste has higher moisture

[49] Maine DEP. *Maine Fuel/Process Rates Totals for 1996*, (ReportSmith edition), Augusta, Maine: Department of Environmental Protection, 1998.

content, which may decrease combustion efficiency. Therefore, the CDD/CDF emission potential of wood combustion is greater than that of fossil fuel combustion.[50] Therefore, the CDD/CDF air emission potential of wood, as reflected in the emission factor available, is greater than other fossil fuels.

2.7.1.2 Emissions

In 1996, nine paper mills in Maine reported the amounts of wood, bark, and wood waste combusted as 3,510,049 tons. These mills report under the Source Classification Code (SCC) of "Industrial and Commercial" facilities (10200901 to 10200908). The application of the EPA emission factor 8.20E-01 ng TEQ/kg wood resulted in 2.61E+00 grams TEQ dioxin emitted.

2.7.2 Waste Tire Incineration

2.7.2.1 Background

Waste tires are incinerated for energy recovery and disposal purposes. Tires are combusted as supplemental fuel in boilers, especially in the pulp and paper industry. In 1996 Maine had one paper mill that incinerated 19,907 tons of tires. Other facilities have reported waste tire incineration in past years and it is possible that more facilities may incinerate tires in the future.

2.7.2.2 Emissions

There are limited emissions data and test reports for tire incineration facilities at the time this report was prepared. The emission factors for total CDD/CDF and TEQ in units of TEQ/kg of tire combusted were developed from emissions test results at one facility in California. This facility uses a spray dryer and flue gas desulfurization followed by a fabric filter to control emissions.[51] [52] Whereas the control devices are the same for the Maine facilities, these emission factors were applied to the amount of tires incinerated. Application of the EPA emission factor of 0.282 ng TEQ/kg tire incinerated resulted in 5.09E-03 grams TEQ dioxin emitted.

2.8 Introduction to Waste Incineration

Waste incineration consists of various combustion processes that are utilized to reduce the bulk mass of waste materials. Types of waste incineration that are potential sources of dioxin/ furan (CDD/CDF) emissions include:

- Municipal waste combustion,
- Industrial or commercial waste incineration,
- Medical waste incineration,
- Municipal sewage sludge incineration, and
- Hazardous waste incineration.

In 1996, Maine’s waste incineration consisted of municipal solid waste and medical solid waste. In previous years industrial solid waste was also burned.

2.9 Municipal Waste Combustion

2.9.1 Background

Municipal wastes are combusted primarily to sterilize and reduce waste volume before disposal. Municipal waste combustion is used as an alternative to landfilling; heat energy recovery may also be associated with the process. EPA studies have shown that the wastes burned in municipal waste combustors (MWCs) come primarily from residential sources.[53] Commercial and industrial sources also contribute to the total waste load to MWCs.

---

[50] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*

[51] Radian Corporation. *Modesto Energy Company Waste Tire-to-Energy Facility, Westley, California*, Final Emission Test Report. Report No. 243-047-20. Research Triangle Park, North Carolina: Radian Corporation, 1988.

[52] U.S. EPA. *Estimating Exposure to Dioxin-Like Compounds*, Volume II: Properties, Sources, Occurrence, and Background Exposures, External Review Draft. EPA-600/6-88-005bC. Washington, D.C.: U.S. Environmental Protection Agency, Exposure Assessment Group, Office of Health and Environmental Assessment, June 1994.

[53] U.S. EPA. *Municipal Waste Combustion Assessment: Technical Basis for Good Combustion Practice*. EPA-600/8-89-063. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1989.

Three types of MWCs are present in Maine, mass burn, modular, and refuse-derived fuel (RDF)-fired. Some MWCs fire only RDF, but RDF may also be co-fired with other fuels. In Maine, wood, oil, liquefied petroleum gas, and natural gas are used in co-fired RFD combustors.

2.9.2 Refuse-Derived Fuel-Fired Combustors:

RDF is municipal solid waste that has been processed to varying degrees, from simple removal of bulky and noncombustible items accompanied by shredding, to extensive processing to produce a finely divided fuel suitable for co-firing in pulverized coal-fired boilers. Processing municipal solid waste to RDF generally raises the heating value of the waste slightly because many of the noncombustible items have been removed.[54] Maine has two RFD combustors, MERC and PERC.

2.9.3 Mass Burn Combustors

Mass burn combustors use gravity or mechanical ram systems to feed MSW onto a moving grate where the waste is combusted. Historically, mass burn combustors have been used to combust MSW that has not been preprocessed except to remove items too large to go through the feed system. Waste that has been processed to remove recyclable materials can also be combusted in these units. Mass burn combustors range in size from 46 to 900 Mg/day (50 to 1000 tpd) and are assembled in the field.[55] Maine had two Mass Burn Waterwall facilities in operation during 1993, Frenchville and Harpswell, however they are non functional as of 2000.

2.9.4 Modular Combustors

Modular combustors are similar to mass burn combustors in that the waste burned has not been preprocessed, but modular combustors are generally smaller in size [4.5 to 103 Mg/day (5 to 140 tpd)] and are shop-fabricated. The most common type of modular combustor is the starved-air or controlled-air type (MOD/SA). Another type, which is similar from a combustion standpoint to the larger MB/WW systems, is referred to as an excess-air combustor (MOD/EA).[56] Maine has two Modular Starved Air combustor, MMWAC and RWS.

2.9.5 Emissions

Emissions of CDD/CDF and other organics from MWCs are most effectively controlled first by following “good combustion practices” and, second by proper operation of an effective air pollution control system. “Good combustion practices” minimizes in-furnace CDD/CDF generation, PM carryover, and low-temperature secondary formation of CDD/CDF. Minimizing in-furnace generation of CDD/CDF is accomplished by optimizing waste feeding procedures, achieving adequate combustion temperatures, providing the proper amount and distribution of combustion air, and optimizing the mixing process. Following these practices will promote combustion of the waste and destruction of CDD/CDF and other organics.[57]

Organics, including CDD/CDF, can exist in the vapor phase or can be condensed or absorbed onto fine particulate and exist as PM. Therefore, minimization of PM carryover from the combustion chamber into the flue gas can result in a decrease in CDD/CDF emissions. PM carryover can be minimized by maintaining appropriate operating load, combustion air flow rates, and air distributions. For a given combustor design, total air flows are directly related to operating load because each combustor is designed to maintain a relatively constant excess air level. As operating load increases above design limits, air flows increase proportionally and the potential for PM entrainment and carryover increases. Therefore, a limit on maximum operating load can assist in minimizing CDD/CDF emissions.[58]

Secondary CDD/CDF formation downstream from the furnace can occur in PM control devices (e.g., ESPs). CDD/CDF formation can occur in the presence of excess oxygen over a wide range of temperatures, with maximum formation rates occurring near 570? F (300? C).[59] At temperatures above 570? F, thermal degradation of CDD/CDF can occur. At lower temperatures, the rate of CDD/CDF formation decreases. At PM control device temperatures of 300 to 570? F (150 to 300? C), CDD/CDF formation can occur. CDD/CDF concentrations vary by approximately a factor of two for each 86? F (30? C) change in temperature (e.g., reducing the operating temperature of the PM control device from 356? F (180? C) to 302? F (150? C) will reduce CDD/CDF emissions by a factor of approximately two). To reduce emissions of CDD/CDF, the maximum inlet temperature on the PM control device should be

[54] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*
[55] *op. cit.*, . AP-42, 5th ed., Section 2.1, Refuse Combustion. 1995.
[56] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*
[57] Ibid.
[58] U.S. EPA. *Municipal Waste Combustion Assessment: Technical Basis for Good Combustion Practice*. EPA-600/8-89-063. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1989.
[59] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans.*

reduced to the lowest practical operating temperature (e.g., by using a spray dryer or water sprays in combination with the PM control device).[60]

EPA currently is attempting to better understand secondary formation of CDD/CDF in existing MWCs, to be able to determine CDD/CDF emissions from MWCs with and without secondary formation of CDD/CDF.

The emission factors presented in the EPA Draft document "Inventory of Sources of Dioxin in the United States" were not used in this report because stack test data is available.

2.9.6 Dioxin Emissions Based on Stack Test of Municipal Waste Incinerators in Maine.

Several years of stack test data were averaged to determine the CDD/CDF emissions because no major changes impacting CDD/CDF emissions occurred at the facilities. The average dioxin test results show an estimated 4.30E-03 pounds, or 1.95E+00 grams of dioxin emissions.[61]

2.10 Industrial and Commercial Waste Incineration

Industrial wastes are non-hazardous materials generated by a process or operation. These wastes are deemed worthless and cannot be further refined or recycled to produce a product. Almost all industries generate some type of waste. Industries that generate combustible wastes such as wood, paper, or plastic sometimes incinerate their own wastes. Incineration of these wastes is a disposal method and it also provides a source of energy that can be captured and used in a process or operation.

For 1996 no facilities reported combustion of solid waste.

2.11 Medical Waste Incineration

2.11.1 Background

Medical waste incineration is the burning of infectious and solid wastes produced by hospitals or similar facilities such as veterinary facilities, crematories, and research facilities.

The primary purposes of medical waste incinerators (MWIs) are to render the waste innocuous, and to reduce the volume and mass of the waste. These objectives are accomplished by (a) exposing the waste to high temperatures over a sufficiently long period of time to destroy threatening organisms, and (b) burning the combustible portion of the waste. The disadvantages of incinerating medical wastes include the generation of ash requiring disposal and the potential release of air toxic emissions.[62]

Medical waste composition, like municipal solid waste, is highly variable. The composition of medical waste is approximately 65 percent paper, 30 percent plastics, and 10 percent water.[63]

2.11.2 Emissions

As with other waste incinerators, emissions of dioxin/ furans (CDD/CDF) and other organics from medical waste incinerators are most effectively controlled by following "good combustion practice" and by collection of PM in an air pollution control device. Following "good combustion practice" can maximize destruction of organics in the furnace. Organics, including CDD/CDF, can exist in the vapor phase or can be condensed or absorbed onto fine particulate; therefore, control of PM emissions can result in a decrease in CDD/CDF emissions.[64]

The emissions from medical waste incinerators were calculated by applying the EPA emission factor of 9.25E+04 ng TEQ/ton, which assumes no emission controls and waste handled at less than 200 pounds per hour, to the 1996 Criteria Inventory reported amount of 179 tons of medical waste resulting in an estimated emissions of 15 grams TEQ dioxin. For 1996 two facilities reported, Jackson Laboratories (97 tons) and Mid-Maine Medical Center, Thayer Unit (82 tons). This means that in 1996 dioxin emissions from these facilities was 15 grams TEQ dioxin. However, since then one facility has closed and the remanding facility is undergoing a process change including source separation to reduce their dioxin emissions. There are also two small facilities that did not report to the 1996 Criteria Inventory, the Ft. Kent and Calais hospitals. For the year 2000, Ft. Kent reported 8 tons (personal

[60] Op. Cit., U.S. EPA. *Municipal Waste Combustion Assessment: Technical Basis for Good Combustion Practice.*
[61] Maine dioxin inventory 1997, Email notes from DEP engineers for stack test of MWCs for dioxin.
[62] American Hospital Associates. *Hospital Statistics*, 1986 ed. Chicago, Illinois: American Hospital Associates, 1986.
[63] Ibid.
[64] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans.*

correspondence 1/2001) and Calais Regional and Downeast Community Hospital reported 12 tons (personal correspondence 12/2000). Thus the 20 tons of medical waste applied to the above emission factor results in an estimated 1.68 grams TEQ dioxin.

2.12 Crematories

2.12.1 Emissions

Dioxin emissions from crematories were calculated by applying the EPA emission factor of 5.00E-01 ug TEQ/body to the number of bodies cremated in 1999. A DEP telephone survey to the five cremation facilities in Maine recorded 5,260 bodies cremated.[65] The resulting estimated emissions are 2.63E-03 grams TEQ dioxin emitted.

2.13 Manufacturing

There are several manufacturing sources of dioxin in Maine. Presently only two source categories can be calculated for dioxin emissions, Portland cement and chlorine production. Two other categories asphalt mixing plants and textile manufacturing currently lack process data in Maine. Another potential manufacturing source is from dry cleaners; however, the process that emits dioxin is not used in Maine. Therefore, dioxin emissions from dry cleaners were not calculated.

2.13.1 Portland Cement, Wet Process

2.13.1.1 Background

This process uses high temperature to convert mineral feed stock into Portland cement and other types of construction materials. EPA has identified two types of Portland cement processes; those that burn hazardous waste and those that do not.[66] The facility in Maine is of the latter type however, some of the combustion material include waster motor oil and landfill leachate.

There are four primary components in Portland cement manufacturing: raw materials handling, kiln feed preparation, pyroprocessing, and finished cement grinding. Pryoprocessing is the fuel intensive process accomplished in cement kilns and has been identified as a potential source of CDD/CDF emissions.[67]

In Portland cement production, most raw materials are quarried on site and transferred by conveyor to crushers and raw mills. After the raw materials are reduced to the desired particle size, they are blended and fed to a large rotary kiln. The feed enters the kiln at the elevated end and the burner is located at the opposite end. The raw materials are then changed into cementitious oxides of metal by a countercurrent heat exchange process. The materials are continuously and slowly moved to the lower end by rotation of the kiln while being heated.[68]

In the wet process, which the Maine facility employs, the material is mixed into wet slurry providing a more uniform and consistent material mixing, resulting in a higher quality clinker. However, more fuel is required for the wet process. The Maine facility utilized wood, coal, coke, fuel oil, waste motor oil, and landfill leachate to supplement the heating process. The facility is also licensed to incinerate whole tires, however this did not assist the heating process and this process is presently suspended.

2.13.1.2 Emissions

The raw materials used for Portland cement production may contain organic compounds, which contain precursors for CDD/CDF formation during the heating step. Fuel combustion to heat the kiln is also a source of CDD/CDF emissions.[69]

The EPA source emissions data base consisted of test reports for CDD/CDF emissions from 12 cement kilns burning hazardous waste and 11-non hazardous waste fueled Portland cement plants. Stack test data from non-hazardous waste fueled facilities were derived from testing during normal operations.[70] The CDD/CDF TEQ emission factor for non-hazardous waste fueled Portland cement wet process was utilized to determine emissions in Maine.

The emissions from Portland cement, wet process were calculated by applying the EPA emission factor of 0.29 ng TEQ/ Kg clinkers to the 1996 Criteria Inventory reported amount of 413,902 tons of clinkers. This results in an estimated emission of 1.09E-01 grams TEQ dioxin emitted.

---

[65] DEP Cremation Telephone survey for mercury emissions, February 2000.
[66] Op. Cit., EPA Draft “Inventory of Sources of Dioxin in the United States”
[67] Ibid.
[68] Ibid.
[69] Ibid.
[70] Ibid.

2.13.2 Chlorine Production

2.13.2.1 Background

Chlorine gas is produced by electrolytic cells process of cathode /electrode reaction with intense electricity. Until the late 1970s, mercury cells containing graphite electrodes were the primary types of electrolytic process used in the chloralkali industry to produce chlorine. The Maine facility was one of these types. However, this facility changed from graphite to another electrode type. Sampling of graphite electrode sludge from European chlorine manufactures indicates high levels of CDFs.[71]

Although the origin of CDFs in graphite electrode sludge is uncertain, chlorination of the cyclic hydrocarbons (such as dibenzofuran) present in coal tar used as a binding agent in the graphite electrodes has been proposed as the primary source. However, the Swedish study also included results from non-graphite electrolysis that also contained high levels of CDFs. It was suggested that chlorinated PAHs (polycyclic or polynuclear aromatic hydrocarbons) present in the rubber linings of the electrolytic cell may have formed the CDFs.[72]

2.13.2.2 Emissions

Emissions from chlorine production were calculated by applying the EPA emission factor of 4.90E+00 pg TEQ/L chlorine produced to the facility's licensed amount of 128,019 liters (liquid)/per day production of chlorine or 4.67E+07 liters/year. Thus resulting in an estimated emission of 2.29E-04 grams TEQ dioxin. It is noted that in practicality this facility does not produce only liquid chlorine; however, in taking a conservative approach for public health the maximum emissions were calculated by assuming all chlorine was liquid.

2.14 Mobile Emissions

Several studies have reported detecting CDD/CDFs in used motor oil. Incomplete combustion and the presence of a chlorine source in the form of additives in the oils or the fuel (such as dichloroethane or pentachlorophenate) were speculated to lead to the formation of CDD/CDFs.[73]

One emission factor is available for mobile source emissions of dioxin, Total On Road Vehicles. The Vehicles Mile Traveled (VMT) for 2000 as estimated from the Maine Department of Transportation (DOT) of 13,585,234,327 was applied to the EPA emission factor of 1.70E+00 pg TEQ/km driven resulting in 3.72E-02 grams TEQ dioxin.

2.15 Potential Sources of Dioxin/ Furan in Maine that are presently not quantifiable

Several of the dioxin/ furan (CDD/CDF) air emission sources identified in the EPA L&E document are not quantifiable in Maine for various reasons; however, there is knowledge of their activity.[74] This report will concentrate on an overview of the sources, and identify the data needed for future emissions estimates.

2.15.1 Iron and Steel Foundries/ Scrap Metal Melting & Combustion-Aided Metal Recovery

Based on Source Classification Codes (SCC), it is known that several of these types of facilities are in Maine. Emission factors are available from the L&E document, however the process rates/ tonnage for the Maine facilities are presently not available, as none of the potential facilities are subject to air licenses, nor have they been inventoried regarding process rates.

2.15.2 Agricultural Burning and Accidental Fires

This section describes CDD/CDF formation from agricultural burning, forest fires, and structure (building) and PCB fires, and their associated emission factors.

2.15.2.1 Forest Fires and Agricultural Burning

---

71 Ibid.
72 Ibid.
73 Ibid.
74 Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans.*

The burning of forested lands occurs through controlled prescribed burning and through uncontrolled accidental forest fires. Prescribed burning is the application and confinement of fire under specified weather, fuel moisture, and soil moisture conditions to accomplish planned benefits such as fire hazard reduction, control of undesired species, seedbed and site preparation, wildlife habitat improvement, and tree disease control.[75] Controlled burning is practiced throughout Maine. Uncontrolled forest fires (wildfires) are fires that are started naturally (e.g., by lightening), accidentally, or intentionally that burn and spread in generally unpredictable patterns.[76]

The types of agricultural waste subject to burning in Maine include residues such straw and stubble in hay fields, orchard pruning and natural attrition losses, grass straw and stubble, potato vines, blueberry barrens, and farmland grass and weeds.

2.15.2.1.1 Emission Factors

Although the potential for emissions exists, dioxin/ furan emission factors have not been identified for agricultural burning.

2.15.2.2 Structure Fires

The most readily identifiable types of open-burned refuse materials are yard waste (branches and other clippings), and barrel burning of household refuse. Structure fires are similar to open refuse barrel burning in that the types of materials combusted are similar (e.g., wood, paper, plastic, textiles, paints, etc.).

In open refuse burning and structure fires, combustion conditions are typically poor and are highly variable because of variations in air flow, fuel moisture content, oxygen levels, material configuration, and degree of exposed surface area. In addition, some refuse or building materials may contain organic constituents that are CDD/CDF precursors or that accelerate dioxin/ furan formation.[77]

2.15.2.2.1 Emission Factors

CDD/CDF emission factors have not been identified for miscellaneous open burning or structure fires.

2.15.2.3 PCB Fires

Fires involving PCB-containing electrical equipment such as transformers and capacitors can result in dioxin/ furan formation and emissions. Electrical equipment containing PCB may catch fire or explode as a result of a fire in a building containing such equipment, or during lightening strikes or electrical surges.

2.15.2.3.1 Emission Factors

Gaseous emissions from PCB fires have not been measured and CDD/CDF emission factors are not available. However, the presence of CDD/CDF in soot from PCB fires has been confirmed in several studies.[78]

2.15.2.3.2 Source Locations

Transformers and capacitors containing PCBs are widely distributed throughout the State of Maine. They are located at electrical substations, in commercial and industrial buildings, mounted on utility poles, in railroad locomotives, and in mining equipment motors. Although the installation of new PCB-containing equipment has been banned and regulations regarding existing ones have been implemented, there are millions of existing PCB transformers and capacitors currently in use in the United States.[79]

Electrical companies are required to keep records of transformers tested for PCB's as well as PCB concentrations of spillage, and accidental releases such as explosions or fires. The PCB laden oils are collected from retiring transformer/ capacitors and shipped of site as hazardous waste.

2.15.3 Municipal Solid Waste Landfills

CDD/CDF emissions can result from flares or other combustion methods that are used to burn "off-gases" that emanate from landfills. Only one test report is available from EPA that summarized CDD/CDF emissions from a landfill dump equipped with waste gas flares. Emissions from landfills in Maine were not determined due to a lack of data. The Maine DEP does not require air emission licenses for afterburners on landfills. Several are known to exist in Maine but no data has been collected.

---

[75] Ibid.
[76] Ibid.
[77] Ibid.
[78] U.S. EPA. *National Dioxin Study Tier 4--Combustion Sources: Final Literature Review*. EPA-450/4-84-014i. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1986.
[79] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans*

2.15.4 Asphalt Production with Contaminated Soil

Typically asphalt production does not produce dioxin/ furan (CDD/CDF) emissions, however when soil containing PCB's, PCP's, or CDD/CDF is utilized as raw material stock, CDD/CDF may be produced. Several of Maine's asphalt batch plants process these types of soils. The intent is to bind the contaminant in the asphalt to reduce mobility within the ecosystem. This section describes the asphalt production process, and associated emission factors that can be applied to this category.

2.15.4.1 Emission Factors

Emission factors for CDD/CDF from asphalt production with contaminated soil, or information from which emission factors may be developed, are not readily available. Emissions depend on the constituents in the contaminated soil being used, and waste contaminants often vary greatly from location to location. Therefore, CDD/CDF emission factors developed for one soil contaminant would be specific only to that type.

The following table presents emission factors developed from information contained in one test report that incinerated PCB contaminated soils. This report presents the results of a test program performed at EPA's Incineration Research Facility (IRF).[80]

Table 2: Emission Factors for CDD/CDF from PCB Contaminated Soil Incineration.

CDD/CDF EMISSION FACTORS FOR A HAZARDOUS WASTE INCINERATOR BURNING PCB-CONTAMINATED SEDIMENTS FACTOR QUALITY RATING: E Emission Factors (a) lb./ton Refuse Combusted			
Isomer		Range	
DIOXINS	Average	Minimum	Maximum
2,3,7,8-TCDD	1.7x10-10	1.6x10-10	1.8x10-10
Total TCDD	6.4x10-10	4.2x10-10	9.4x10-10
Total PeCDD	3.8x10-10	2.6x10-10	5.7x10-10
Total HxCDD	5.1x10-10	4.2x10-10	6.5x10-10
Total HpCDD	9.3x10-10	4.7x10-10	1.3x10-9
Total OCDD	2.5x10-9	1.6x10-9	3.4x10-9
FURANS			
2,3,7,8-TCDF	1.9x10-8	1.4x10-8	2.7x10-8
Total TCDF	1.1x10-7	7.8x10-8	1.6x10-7
Total PeCDF	2.9x10-8	1.7x10-8	4.6x10-8
Total HxCDF	6.5x10-9	4.0x10-9	7.9x10-9
Total HpCDF	5.1x10-10	1.1x10-10	1.1x10-9
Total OCDF	7.3x10-10	5.7x10-10	8.5x10-10

Source; EPA L&E table 4.9

Overall, it appeared that emissions of CDD/CDF from soil contaminated with PCB's were not significant, but they can occur. As with other types of refuse combustion; CDD/CDF emissions from these types of facilities are highly dependent on the type of waste feed and incinerator operating practices.

Determination of air emissions from this source can not be completed at this time because the quantity of contaminated soil used for asphalt production is not known, as well as incineration of soils contaminated with compounds other than PCB. There are several facilities licensed in Maine that can use "up to 10,000 cubic yards of petroleum contaminated soil," but the actual amount is not known.

SECTION 3. SUMMARY OF EMISSIONS

This section attempts to compile the emission estimates utilizing the emission factors for sources of CDD/CDF TEQ in Maine. Not every contributing source is quantifiable, primarily due to a lack of data at this time. All emission factors were taken from EPA Draft document “Inventory of Sources of Dioxin in the United States” (EPA/600/P-98/002a), April 1998, which contains the most recent dioxin Total Equivalent Toxicity (TEQ) emission factors available.[81] Calculations and conversions are presented in section 3 of this document.

---

[80] Op.Cit., U.S. EPA. *Locating and Estimating Air Emissions from Sources of Dioxins and Furans.*

[81] EPA Draft “Inventory of Sources of Dioxin in the United States” (EPA/600/P-98/002a), Office of Research and Development, Washington, D.C., April 1998.

The following is the summation table of dioxin sources in Maine utilizing the EPA emission factor.

Table 3: Maine Dioxin/Furan Emissions in TEQs.

Source	Lbs. TEQ	Grams TEQ	Percentage
Residential; bituminous	1.94E-06	1.36E-02	0.05
Residential; #2 fuel oil	2.60E-05	1.82E-01	0.61
Residential wood combustion	5.49E-03	2.49E+00	8.33
Back Yard Burning	2.15E-03	9.73E-01	3.25
Total Residential combustion	**7.67E-03**	**3.66E+00**	12.24
Wood, industrial non P&P mills	3.54E-04	1.61E-01	0.54
Residual Commercial Oil	7.23E-05	3.28E-02	0.11
Wood - P&P Mills	5.76E-03	2.61E+00	8.73
Tire waste combustion (Paper mills)	1.12E-05	5.09E-03	0.02
Total Commercial & industrial	**6.20E-03**	**2.81E+00**	9.39
Wood - Utility	2.20E-03	9.98E-01	3.34
Oil-Fired Utility Boilers	8.85E-05	4.01E-02	0.13
Total Utility Boilers	**2.29E-03**	**1.04E+00**	3.47
Municipal waste incinerators	4.30E-03	1.95E+00	6.52
Medical Waste Incinerators	3.31E-02	1.50E+01	50.17
Crematories	5.80E-06	2.63E-03	0.01
Cement Production, Wet Process	2.40E-04	1.09E-01	0.36
Chlorine production	5.05E-07	2.29E-04	0.00
Total On Road Vehicles	8.20E-05	3.72E-02	0.12
Maine State Total CDD/CDF in TEQ	**0.05**	**24.60**	**100.00**

SECTION 4. ON-GOING REPORT

This section identifies some potential sources of dioxin/ furan air emissions in Maine which were unquantifiable for various reasons. The intent is for on-going reports to address these deficiencies of data.

- .**Mobile Sources**- Several categories of mobile sources are not quantifiable at this time. Off-Road mobile sources need an emission factor. On Road Diesel sources emission factors as pound per Vehicle Mile Traced (lb/vmt) needs to be identified. Presently a TEQ emission factor is used.
- **Portland Cement Manufacturing-** The quantity of municipal solid waste landfill leachate used, and an emission factor needs to be identified. As well as emission factors for waste oil combustion.
- **Paper Mills-** Quantities of wastewater sludge incineration, concentrations of dioxin/ furan in the sludge, and emission factors.
- **Iron and Steel Foundries-** Identify the facilities and the tonnage of metal cast.
- **Open Burning-** Quantify areas burned and conversion of burn areas to tonnage.
- **Burn Barrels-** Quantify source statewide, estimate tonnage.
- **PCB Fires-** Gather documentation of accidental fires from electric companies, including PCB concentrations. Identify emission factors.
- **Municipal Solid Waste Landfills-** Identify operations that utilize afterburner controls, and determine the Btu's per year combusted.
- **PCP Wood Treatment-** Identify facilities and tonnage of wood treated.
- **Asphalt Production with Contaminated Soil-** Identify the quantity and concentration of PCP/PCB contaminated soil utilized by this source. Identify emission factors for PCP's in soil combustion.

SECTION 5. CALCULATION DESCRIPTIONS FOR THE DIOXIN INVENTORY 2000.

For the 2000 Maine Dioxin Emission Inventory the EPA Draft “Inventory of Sources of Dioxin in the United States” (EPA/600/P-98/002a) was used as guidance and most all the emission factors are from this publication, unless otherwise noted.

Dioxin sources were segregated into various categories: residential, utility, manufacturing, commercial & industrial, waste combustion and mobile. Each major category is comprised of several subcategories.

Table 4: Dioxin Source Categories.

Residential	Utility	Manufacturing
Residential bituminous coal	Wood – Utility Boilers	Cement Production, Wet Process
Residential #2 fuel oil	Oil-Fired Utility Boilers	Chlorine production
Residential wood combustion		Textile mfg.
Back yard burn barrels	Mobile	Asphalt mixing plants
	Total On Road Vehicles	Dry Cleaners
Commercial/ Industrial		
Wood, industrial non P&P mills	Waste Combustion	
Residual Commercial Oil	Municipal waste incinerators	
Wood - P&P Mills	Medical Waste Incinerators	
Tire waste combustion (Paper mills)	Crematories	

5.1 Emissions Summary

The following is the summation table of dioxin sources in Maine utilizing the EPA emission factor.

Table 5: Maine 2000 Dioxin Inventory Summary.

Source	Lbs. TEQ	Grams TEQ	Percentage
Residential; bituminous	0.00000194	0.0136	0.10
Residential; #2 fuel oil	0.000026	0.182	1.29
Residential wood combustion	0.00698985	3.17	22.47
Back Yard Burning	0.00215	4.05	28.70
Total Residential combustion	**0.00916779**	**7.4156**	**52.56**
Wood, industrial non P&P mills	0.000354	0.177	1.25
Residual Commercial Oil	0.0000723	0.0328	0.23
Wood - P&P Mills	0.00576	2.88	20.41
Tire waste combustion (Paper mills)	0.0000112	0.00509	0.04
Total Commercial & industrial	**0.0062**	**3.09489**	**21.93**
Wood – Utility	0.0022	1.1	7.80
Oil-Fired Utility Boilers	0.0000885	0.0401	0.28
Total Utility Boilers	**0.00229**	**1.1401**	**8.08**
Municipal waste incinerators	0.0043	1.95	13.82
Medical Waste Incinerators	0.00315	1.68	11.91
Crematories	0.0000058	0.00263	0.02
Cement Production, Wet Process	0.00024	0.109	0.77
Chlorine production	0.000000505	0.00000000902	0.00
Total On Road Vehicles	0.000082	0.0372	0.26
Maine State Total CDD/CDF in TEQ	**0.025432095**	**15.42942**	**100.00**

5.1.1 Residential Coal Combustion

The emission factor for residential bituminous coal combustion is 7.50E+00 ng TEQ/kg bituminous coal combusted. The process amount for this category was derived through the Maine State Planing Office (SPO). For 1997 2,000 tons of bituminous coal was combustion resulting in 1.36E-02 grams TEQ dioxin emitted.

Calculations

First convert the 2,000 tons to kilograms.

2,000 tons X 9.07E+02 = 1814360 kilograms.

Multiply the kilograms combusted by the emission factor.

1814360 kilograms X 7.50E+00 ng TEQ/kg bituminous coal combusted

= 1.36E+07 nanograms TEQ (emission factor x kilograms)

Conversion of nanogram to grams emitted.

1.36E+07 nanograms TEQ (emission factor x kilograms)X 1.0E-09 nanograms to grams

= 1.36E-2 grams TEQ dioxin

5.1.2 Residential #2 Fuel Combustion

The emission factor for residential #2 fuel combustion is 1.50E+02 pg TEQ/L #2 oil combusted. The process amount for this category was derived through the Maine State Planing Office (SPO). For 1997 7,644 Thousand barrels of #2 fuel was combustion resulting in 0.182 grams TEQ dioxin emitted.

Calculations

First convert the 7,644,000 barrels to liters. The AP-42 conversion factor is 158.98 barrels (petroleum U.S.) to liters.

7,644,000 barrels X 158.98 barrels (petroleum U.S.) to liters

= 1.22E+9 liters

Multiply the liters combusted by the emission factor.

1.22E+09 liters X 1.50E+02 pg TEQ/L #2 oil combusted

= 1.83E+11 pg TEQ dioxin.

Convert picograms to grams

1.83E+11 pg TEQ dioxin X 1.0E-12 picograms to grams

= 1.82E-01 grams TEQ dioxin

5.1.3 Residential Wood Combustion

Residential wood combustion comprises several sub categories depending on the method of combustion, wood stove, wood furnace or boiler, fireplace, catalytic wood stoves and pelleted wood stove. The later two sub categories have been combined into a category of “other” due to the data received from a SPO survey.

The emission factor for residential wood combustion is 2.00E+00 ng TEQ/kg wood combusted. The process amount for this category was derived through the State Planing Office (SPO) and Department of Energy (DOE) numbers for 1997. The SPO survey showed 78.85% of the purchased wood was for wood stoves, 5.77% for fireplaces, 12.5% furnace or boiler, and 2.88% for others. Of interest is that the SPO reported 25% of the people who burned wood in 1998/99 did not purchase it. Therefore the SPO and Department of Energy (DOE) numbers of how much wood is purchased for combustion is approximately 75% of the total residential wood combusted. The estimated emission for total residential wood combustion is 2.49 grams TEQ dioxin.

Calculations

The DOE survey reported 469,862 cords of wood for residential combustion was sold in 1997. With the 25% increase for unrecorded use of 117,465.50 cords, resulting in a total of 587,327.5 cords of wood combusted.

Convert cords to tons

587,327.5 cords of wood X 2.34 tons per cord (AP-42) = 1,371,997.04 tons

Convert tons to kilograms

1,371,997.04 tons X 9.07E+02 = 1.24E+09 kilograms

Multiply the kilograms combusted by the emission factor.

1.24E+09 Kilograms X 2.00E+00 ng TEQ/kg wood combusted = 2.49E+09 ng TEQ dioxin

Conversion of nanogram to grams emitted.

2.49E+09 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 2.49E+00 grams TEQ dioxin.

Section 5.2.4 Back Yard Burn Barrels (BYB)

Determination of dioxin emissions from Back Yard Burning (BYB) was derived through application of a DEP estimated process tonnage and application of the EPA emission factor. The EPA Draft "Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)[82] utilized the "Evaluation of Emissions from the Open Burning of Household Waste in Barrels," (EPA-600/R-977-134a)[83] to derive a 140 ng TEQ/Kg trash burned emission factor. This emission factor was derived assuming that recyclable materials were not removed prior to burning. EPA also gave a value of zero to dioxin/furan isomers not detected at the detection level, although it is known that minute quantities of the isomer were likely present. It is common practice to assign a value of half the detection limit, if it is known that a chemical is present, but cannot be quantified adequately using present technology. DEP used this convention to derive a 583 ng TEQ/kg waste emission factor for BYB.

In 1997 DEP conducted a survey of towns that do not recycle trash or have curb-side trash pick up service.[84] This report estimated that 7,665 tons of trash was burned in 1996. Application of the emission factor and the estimated tonnage results in 0.973 grams TEQ dioxin.

Calculations

Convert the tons to kilograms

7,665 tons X 9.07E+02

= 6.95E+06 kilograms

Multiply the kilograms combusted by the emission factor.

6.95E+06 kilograms X 583 ng TEQ/Kg trash burned

= 4.05 E+09 ng TEQ dioxin

Conversion of nanogram to grams emitted.

4.05 E+09 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 4.05 grams TEQ dioxin.

Note: Using the EPA 140 ng/kg emission factor yield 0.973 grams TEQ of dioxin.

5.2 Commercial and Industrial Combustion

This section is comprised of four categories, wood combusted by non-paper mills, wood combusted by paper mills, commercial residual oil combustion, and waste tire combustion. EPA emission factors were applied to each category for estimated TEQ dioxin emission.

5.2.1 Wood Combustion by Non-Paper Mills

Determination of the dioxin emissions for this category was derived through the compilation of the process rates for facilities as reported to DEP for the Criteria Pollutant inventory and application of the EPA emission factors. For 1996 facilities reported 215,995 tons of wood were combusted. Application of the EPA emission factor 8.20E-01 ng TEQ/kg wood resulted in 1.61E-01 grams TEQ dioxin

Calculations

Convert the tons to kilograms

---

82 Inventory of Sources of Dioxin in the United States" (EPA/600/P-98/002a)

83 Evaluation of Emissions from the Open Burning of Household Waste in Barrels," (EPA-600/R-977-134a)

84 DEP "State of Maine 1997 Backyard Trash Burning (BYB) Study."

215,995 tons X 9.07E+02

= 1.96E+08 kilograms

Multiply the kilograms combusted by the emission factor.

1.96E+08 kilograms X 8.20E-01 ng TEQ/kg wood

= 1.61E+08 ng TEQ dioxin

Conversion of nanogram to grams emitted.

1.61E+08 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 1.61E-01 grams TEQ dioxin

5.2.2 Commercial Residual Oil Combustion

Emissions from commercial residual combustion was calculated by applying the EPA emission factor of 2.00E+02 pg TEQ/L to the Criteria Inventory reported amount of 43,314 thousand gallons of residual oil.

Calculations

Convert thousand gallons to liters;

43,314 thousand gallons X 3.7854 gallons to liters (AP-42)

= 1.64E+08 liters residual oil

Multiply the liters combusted by the emission factor.

1.64E+08 liters residual oil X 2.00E+02 pg TEQ/L

= 3.28E+10 pg TEQ dioxin

Conversion of picogram to grams emitted.

3.28E+10 pg TEQ dioxin X 1.0E-12 picograms to grams

= 3.28E-02 grams TEQ dioxin

5.2.3 Wood Combusted by Paper Mills

Determination of the dioxin emissions for this category was derived through the compilation of the process rates for facilities as reported to DEP for the Criteria Pollutant inventory and application of the EPA emission factors. For 1996 paper mill facilities reported 3,510,049 tons of wood were combusted. Application of the EPA emission factor 8.20E-01 ng TEQ/kg wood resulted in 2.61 grams TEQ dioxin

Calculations

Convert the tons to kilograms

3,510,049 tons X 9.07E+02

= 3.18E+09 kilograms

Multiply the kilograms combusted by the emission factor.

3.18E+09 kilograms X 8.20E-01 ng TEQ/kg wood

= 2.61E+09 ng TEQ dioxin

Conversion of nanogram to grams emitted.

2.61E+09 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 2.61 grams TEQ dioxin

5.2.4 Waste Tire Combustion

Determination of the dioxin emissions for this category was derived through the compilation of the process rates for facilities as reported to DEP for the Criteria Pollutant inventory and application of the EPA emission factors. For 1996 paper mill facilities reported 19,907 tons of tires were combusted. Application of the EPA emission factor 0.282 ng TEQ/kg tire resulted in 5.09E-03 grams TEQ dioxin

Calculations

Convert the tons to kilograms

19,907 tons X 9.07E+02

= 1.81E+07 kilograms

Multiply the kilograms combusted by the emission factor.

1.81E+07 kilograms X 0.282 ng TEQ/kg tire

= 5.09E+06 ng TEQ dioxin

Conversion of nanogram to grams emitted.

5.09E+06 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 5.09E-03 grams TEQ dioxin

5.3 Utility Combustion

This section is comprised of two categories, wood combustion and Oil fired utility boilers. EPA emission factors were applied to the categories for estimated TEQ dioxin emission.

5.3.1 Wood Utility Boilers

Determination of the dioxin emissions for this category was derived through the compilation of the process rates for facilities as reported to DEP for the Criteria Pollutant inventory and application of the EPA emission factors. For 1996 electric generation facilities reported 1,341,731 tons of wood was combusted. Application of the EPA emission factor 8.20E-01 ng TEQ/kg wood combusted resulted in 9.98E-01 grams TEQ dioxin

Calculations

Convert the tons to kilograms

1,341,731 tons X 9.07E+02

= 1.22E+09 kilograms

Multiply the kilograms combusted by the emission factor.

1.22E+09 kilograms X 8.20E-01 ng TEQ/kg wood

= 9.98E+08 ng TEQ dioxin

Conversion of nanogram to grams emitted.

9.98E+08 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 9.98E-01 grams TEQ dioxin

Section 5.3.2 Oil Fired Utility Boilers

Emissions from oil fired utility boilers were calculated by applying the EPA emission factor of 2.00E+02 pg TEQ/L to the Criteria Inventory reported amount of 53,026 thousand gallons of residual oil.

Calculations

Convert thousand gallons to liters;

53,026 thousand gallons X 3.7854 gallons to liters (AP-42)

= 2.01E+08 liters oil

Multiply the liters combusted by the emission factor.

2.01E+08 liters oil X 2.00E+02 pg TEQ/L

= 4.01E+10 pg TEQ dioxin

Conversion of picogram to grams emitted.

4.01E+10 pg TEQ dioxin X 1.0E-12 picograms to grams

= 4.01E-02 grams TEQ dioxin

5.4 Waste Combustion and Cremations

This section consists of three categories, municipal waste combustion, medical waste combustion and cremations. EPA emission factors were applied to each category for estimated TEQ dioxin emission.

5.4.1 Municipal Waste Combustors

MWCs in Maine are stack tested annually. The average dioxin test results show an estimated 4.30E-03 pounds, or 1.95E+00 grams of dioxin emissions.[85]

5.4.2 Medical Waste Incinerators

Emissions from medical waste incinerators were calculated by applying the EPA emission factor of 9.25E+04 ng TEQ/kg to the Criteria Inventory for 1996 reported amount of 179 tons of medical waste resulting in an estimated emissions of 15 grams TEQ dioxin. Only two facilities reported for 1996, Jackson Laboratories (97 tons) and Mid-Maine Medical Center, Thayer Unit (82 tons). Two other facilities did not report data, Ft. Kent and Machias. The EPA emission factor assumes uncontrolled emissions from facilities handling less than 200 lbs./hr of waste.

Calculations

Convert the tons to kilograms

179 tons X 9.07E+02

= 1.62E+05 kilograms

Multiply the kilograms combusted by the emission factor.

1.62E+05 kilograms X 9.25E+04 ng TEQ/kg medical waste

= 1.50E+10 ng TEQ dioxin

Conversion of nanogram to grams emitted.

1.50E+10 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 1.50E+01 grams TEQ dioxin, or 15 grams TEQ dioxin.

[85] Maine dioxin inventory 1997, email notes from DEP engineers for stack test of MWCs for dioxin

Section 5.4.3 Crematories

Emissions from crematories were calculated by applying the EPA emission factor of 5.00E-01 ug TEQ/body to the number of bodies cremated in 1999. A DEP telephone survey to the five cremation facilities in Maine recorded 5,260 bodies cremated. The resulting estimated emissions are 2.63E-03 grams TEQ dioxin.

Calculations

Multiply the bodies cremated by the emission factor.

5,260 bodies X 5.00E-01 ug TEQ/kg body

= 2.63E+03 ug TEQ dioxin

Conversion of microgram to grams emitted.

2.63E+03 ug TEQ dioxin X 1.00E-6 micrograms to grams

= 2.63E-03 grams TEQ dioxin.

5.5 Manufacturing Sources

There are several manufacturing sources that EPA has identified as dioxin sources. However, only two categories have sufficient data to estimate dioxin emissions; Portland cement, wet process and chlorine production.

5.5.1 Portland Cement, Wet Process

Emissions from Portland cement, wet process were calculated by applying the EPA emission factor of 0.29 ng TEQ/ Kg clinkers for non hazardous Portland cement production to the Criteria Inventory reported amount of 413,902 tons of clinkers resulting in an estimated emissions of 1.09E-01 grams TEQ dioxin.

Calculations

Convert the tons to kilograms

413,902 tons X 9.07E+02

= 3.75E+08kilograms

Multiply the kilograms combusted by the emission factor.

3.75E+08 kilograms X 0.29 ng TEQ/kg clinkers

= 1.09E+08 ng TEQ dioxin

Conversion of nanogram to grams emitted.

1.09E+08 ng TEQ dioxin X 1.00E-9 nanograms to grams

= 1.09E-01 grams TEQ dioxin.

5.5.2 Chlorine Production

Emissions from chlorine production were calculated by applying the EPA emission factor of 4.90E+00 pg TEQ/L chlorine produced to the facility's licensed amount of 128,019 liters (liquid)/per day production of chlorine or 4.67E+07 liters/year. Thus resulting in an estimated emissions of 2.29E-04 grams TEQ dioxin. It is noted that in practicality this facility does not produce only liquid chlorine, however, in tacking a conservative approach for public health the maximum emissions were calculated.

Calculations

Convert the short tons to pounds

128,019 liters (liquid)/per day X 365 days/year

= 46,726,935 liters

Multiply the liters produced by the emission factor.

4.67E+07 L chlorine/ year X of 4.60E+00 pg TEQ/L chlorine produced

= 2.29E+08 pg TEQ dioxin

Conversion of picogram to grams emitted.

2.29E+08 pg TEQ dioxin X 1.00E-12 picograms to grams

= 2.29E-04 grams TEQ dioxin.

5.6 Mobile Emissions

One emission factor is available for mobile source emissions of dioxin, Total On Road Vehicles. The Vehicles Mile Traveled (VMT) for 2000 as estimated from the Maine Department of Transportation (DOT) of 13,585,234,327 was applied to the EPA emission factor of 1.70E+00 pg TEQ/km driven resulting in 3.72E-02 grams TEQ dioxin.

Calculations

Convert miles to kilometers

13,585,234,327 miles X 1.61E+00 Miles to Kilometers (AP-42)

= 2.19E+10 kilometers

Multiply the kilometers driven by the emission factor.

2.19E+10 kilometers X 1.70E+00 pg TEQ/km driven

= 3.72E+10 pg TEQ dioxin

Conversion of picogram to grams emitted.

3.72E+10 pg TEQ dioxin X 1.00E-12 picograms to grams

= 3.72E-02 grams TEQ dioxin.

5.7 Data Needs

Several categories that EPA has identified as dioxin sources are found in Maine that emission estimated were not able to be calculated due to data limitations. These sources are textile manufacturing, asphalt mixing plants, and dry cleaning.

For textile manufacturing the tonnage or kilograms of textile needs to be know. Presently this data is not collected under the Criteria Pollutant Survey/ Inventory. Through previous years of data it was determined that asphalt paving is a small or area source and as a result this data has not been collected in recent years.

Future surveys should be conducted to fill in these data gaps.

Appendix A: Press releases

Contact: Deb Garrett 287-2812 July 26, 1996

FOR IMMEDIATE RELEASE:
DEP ISSUES REPORT ON DIOXIN MONITORING....

(AUGUSTA)--Dioxin concentrations in fish taken from some Maine rivers are significantly lower today than when the problem was first discovered in the mid-to-late 1980s. However, this year's results--the first of a two-year monitoring cycle--show few statistically significant changes from 1994.

The documentation is contained in a report on the state's 1995 Dioxin Monitoring Program. Prepared by the Department of Environmental Protection, the report contains data on fish from rivers below known dischargers of dioxin, including certain pulp and paper mills, tanneries, and textile mills. The 1995 Dioxin Monitoring Program data have been sent to the Bureau of Health for review.

While the 1994-1995 data are not significantly different, the dioxin concentrations are notably lower than those monitored in the early 1990s. These overall reductions are a result of major reductions in dioxin discharges by the bleach kraft mills in the state.

In the past, the presence of dioxin in Maine fish prompted the Bureau of Health to issue "consumption advisories." These were last revised in 1992 when advisories regarding two of Maine's rivers were lifted.

The current language advises "women of child-bearing age not to eat fish from the Androscoggin River, Kennebec River below Skowhegan, and Penobscot River below Lincoln." The same advisory recommends limits for the general population--one meal per month of fish from the Androscoggin and two meals per month of fish from the designated sections of the Kennebec and Penobscot. Lobster tomalley are also subject to advisories indicating that pregnant women, nursing mothers and women of childbearing age should not eat lobster tomalley and that others should limit their consumption.

Dioxin is found in the environment as a result of a number of different activities, including the incineration of waste. In Maine, Governor King has called on the paper industry to continue to reduce dioxin discharges so that dioxin-based advisories can be eliminated by the year 2000. He has further called on the mills to completely eliminate dioxin discharges in the long term. All Maine's kraft mills have pledged to work toward the ultimate goal of eliminating dioxin discharges. DEP is now working with individual mills to develop plans to modify their technologies or processes to achieve both goals.

The Dioxin Monitoring Program will continue to track the progress through 1997, when it is scheduled to end. DEP plans to introduce legislation to extend the program through the year 2000.

DEP Commissioner Sullivan said: "This report indicates that we still have work to do to achieve the goal of eliminating fish consumption advisories by the year 2000 and the ultimate elimination of dioxin discharges. Maine mills deserve credit for progress to date and we need to maintain momentum toward the goals. The report also indicates the importance of renewing the monitoring program during the coming legislative session. Without sound science on the dioxin levels in fish, we will not have the basis for gauging our progress toward these important goals."

Methodologies for sampling and reporting Program results are established by DEP with the advice of a Technical Advisory Group established by the Maine legislature.

Appendix B: Fish Consumption Advisory 2000

Appendix B1 As seen on the Maine State web site: http://janus.state.me.us/dhs/bohetp/fca.htm

Warnings on Eating Fish Caught in Maine Waters

The Bureau of Health is responsible for recommending the warnings on eating fish based on the presence of chemicals (MSRA 22 § 1696 I).

Fish is Good for You and Your Family if you follow the Eating Guidelines

Fish is good for you and your family. It is a low fat source of protein that is rich in nutrients. Studies have shown that eating fish regularly (such as once per week) can reduce the chance of death from a heart attack. The American Heart Association recommends people eat fish regularly. Fish is also one of the few foods that are rich in the 3-omega fatty acids needed for proper development of the brain and nervous system in the unborn fetus and infants. So be sure to include fish in your diet.

But some fish have chemicals in them that may be harmful if you eat too much. The Bureau of Health issues eating guidelines for fish (called "Fish Consumption Advisories") from Maine waters so you can still get the health benefits of eating fish by choosing safer types of fish, safer places to catch fish, safer ways to prepare fish, and limiting how much certain fish you eat.

Appendix B2. As provided in a downloadable document:

WARNING ABOUT EATING FRESHWATER FISH

Warning: Mercury in Maine Freshwater fish may harm the babies of pregnant and nursing mothers, and young childre. SAFE EATING GUIDELINES **Pregnant and nursing women, women who may get pregnant, and children under age** 8 SHOULD NOT EAT any freshwater fish from Maine's inland waters. Exccept, for brook trout and landlock salmon, 1 meal per month is safe. **All other adults and children older than 8** CAN EAT 2 freshwater fish meals per month. For brook trout and landlocked salmon, the limit is 1 meal per week.	It's hard to believe that fish that looks, smells, and tastes fine may not be safe to eat. But the truth is that fish in Maine lakes, ponds, and rivers have mercury in them. Other states have this problem too. Mercury in the air settles into the waters. It then builds up in fish. For this reason, older fish have higher levels of mercury than younger fish. Fish (like pickerel and bass) that eat other fiish have highest mercury levels. Small amounts of mercury can harm a brain starting to form or grow. That is why unborn and nursing babies, and young children are most at risk. Too much mercury can affect behavior and learning. Mercury can harm older children and adults, but it takes larger amounts. It may cause numbness in hands and feet or changes in vision. The Safe Eating Guidelines identify limits to protect everyone.

Warning: **Some Maine waters are polluted, requiring additional limits to eating fish.**

Fish caught in some Maine waters have high levels of PCBs, Dioxins or DDT in them. These chemicals can cause cancer and other health effects. The Bureau of Health Recomends additional fish consumption limits on the waters listed below. Remember to check the mercury guidelines. If the water you are fishing is listed below, check the mwercury guidline above and follow the most limiting guidelines.

SAFE EATING GUIDELINES

Androscoggin River Gilead to Merrymeeting Bay:------------------------ 6-12 fish meals a year.
Dennys River Meddybumps Lake to Dead Stream: ------------------------1-2 fish meals a month.
Green Pond, Chapman Pit, & Greenlaw Brook
(Linestone): ---**Do not eat any fish from these waters.**
Little Madawaska River & Tributaries
(Madawaska Dam to Grimes Mill Road)--------- **Do not eat any fish from these waters.**
Kennebec River Augusta to Chops: --------------------- **Do not eat any fish from these waters.**
Shawmut Dam in Fairfield to Augusta: ---- **5** trout meeals a year, **1-2** bass meals a month.
Madison to Fairfield: --- **1-2** fish meals a month.
Meduxnekeg River: --- **2** fish meals a month.
North Branch Presque Isle River: --- **2** fish meals a month.
Penobscot River below Lincoln: -- **1-2** fish meals a month.
Prestile Stream: -- **1** fish meals a month.
Red Brook in Scarborough: --- **6** fish meals a year.
Salmon Falls River below Brewick: -- **6-12** fish meals a year.
Sebasticook River (East Brach, West Branch & Main Stream)
(Corinna/Hartland to Winslow): -- **2** fish meals a month.

For more details, including warnings on striped bass, bluefish and lobster tomalley call (207-287-6455 or visit our web site at http://janus.state.me.us/dhs/bohetp/index.htm	Revised August 29, 2000 Environmental toxicology Program Maine Bureau of Health

File Name and Path: H:\AIR\Air Toxics\PBTs\Dioxin\DXN report\Public Release DRAFT 2000 dioxin rpt(8).doc